Policy Statement
for
TESTING OF LIME-MODIFIED AGGREGATE BASE TO DETERMINE PLASTICITY INDEX
In the
City of Mesa, Arizona

BACKGROUND:

In 1974, the City of Mesa adopted the Uniform Standard Specification for Public Works Construction as published by the Maricopa Association of Governments (MAG) as the standards for all work within the public right of way. MAG Section 702.2.3 specifically requires the Plasticity Index be tested in accordance with AASHTO T 146, Method A (Wet Preparation).

The Plasticity Index is a test that will determine the effect that the fine sands and clay particles will have on the aggregate base material. When the Plasticity Index becomes to high, the aggregate base, used in the construction of our streets, will not support the required traffic loading and in turn, will cause premature failure of the streets.

In past years, the quality of aggregate base material provided to the City has met or exceeded the MAG Standard Specifications. However, there is not an infinite supply of this material. Some of the suppliers have depleted their best sources and are forced to provide material with a higher Plasticity Index. Also, with the City extending further to the south and east, away from our normal source of material in the Salt River, the cost of transportation becomes an economical factor. As a result, other sources from the south of the City with lower quality aggregates are becoming economical. Because of these changed conditions, the Plasticity Index has risen above the maximum allowable limit established by the MAG Specifications. Since lime has a neutralizing effect on clay particles, the suppliers are using lime to modify the aggregate in order to meet this criteria.

Through laboratory testing, it has been determined that the lime modified aggregates, when tested by AASHTO T 146 Method A (Wet Preparation), may cause erroneous test results when exposed to air and/or large volumes of water for extended periods of time. Therefore, per this policy, the AASHTO T 146 Method A (Wet Preparation) procedure will be modified to reduce the error to acceptable limits.

In a joint effort, the City of Mesa and the local material suppliers have developed a standard testing procedure for lime-modified aggregate base material. The procedure follows the AASHTO T 146, Method A. The basic modifications in this procedure limit the exposure to air and limit the volume of water used in the test. In this modified test, the amount of water has been reduced to a point that sufficiently cleans the aggregate to keep the test reliable without significantly effecting the test results and keep the exposure to the air at a minimum.

POLICY:

The City of Mesa adopts the Policy for Testing of Lime-Modified Aggregate Base To Determine Plasticity Index. To maintain continuity between the AASHTO test procedures and this policy, this policy has been divided into three sections:

A. Sample Preparation

B. Determining the Liquid Limit

C. Determining the Plastic Limit and Plasticity Index

SECTION A

SAMPLE PREPARATION

I. REFERENCE:

M.A.G. 702.2.3 Plasticity Index
AASHTO T 146, Method A (Wet Preparation)

II. APPLICATION:

Applies to all contract and permit work.

III. BACKGROUND:

M.A.G. 702.2.3 specifically requires the Plasticity Index be tested in accordance with AASHTO T 146, Method A (Wet Preparation). Because of the increased presence of plastic fines in the aggregate pits, many suppliers are using lime to modify the aggregate in order to meet this criteria. Through laboratory testing, it has been determined that the lime modified aggregates may cause erroneous test results when exposed to air and/or large volumes of water for extended periods of time. Therefore, the AASHTO T 146, Method A procedure will be modified as described herein to reduce the error to acceptable limits.

IV. APPARATUS:

1. Weighing Apparatus - A balance that has sufficient capacity and conforms to AASHTO M 231, Class G2.

2. Drying Apparatus - An oven of suitable size that is capable of drying samples at a temperature not exceeding 60°C (140°F).

3. Sieves - A series of sieves of which the minimum opening shall be 19 mm, 4.75 mm, 2.0 mm and 0.425 mm (3/4", # 4, # 10, # 40).

4. Pulverizing Apparatus - A mortar and rubber covered pestle for breaking up the aggregations of soil particles without reducing the size of the individual grains.

5. Sample Splitter - A suitable riffle sampler for proportional splitting of the field sample to obtain a representative sample without an appreciable loss of fines.

6. Miscellaneous Equipment - Pans, buckets, siphon tube, syringe, brushes, etc.

V. PROCEDURE:

1. Reduce the field sample by splitting to a mass of 800 g to 1000 g.

2. Dry the test sample in an oven at 60ºC (140°F) maximum or at room temperature.

3. Any obvious aggregations shall be thoroughly broken down with a mortar and rubber covered pestle. The process shall avoid reducing the natural size of the individual particles. Using the sieves referenced in Section A. IV. 3., separate the dried material into two portions, material retained on the 0.425 mm (# 40) sieve and material passing the 0.425 mm (# 40) sieve.

4. The material passing the 0.425 mm (# 40) sieve shall be placed in a tightly covered container and set aside for later recombination with other processed material from the sample.

5. a.) The material retained on the 0.425 mm (# 40) sieve shall be placed in a pan, leveled and covered with the minimum amount of water that completely immerses all of the material. The sample shall remain in the immersed condition for a minimum of 2 hours and a maximum of 24 hours. During this time, the container shall be tightly covered .

b.) After soaking (Section A. V. 5.a.), wash the material over a 0.425 mm (# 40) sieve in the following manner: An empty 0.425 mm (# 40) sieve shall be placed in the bottom of a suitable container . The soaked material and water shall be poured into the sieve and the material leveled evenly across the sieve. Water shall be added to a level that just covers all of the material retained on the sieve. Stir the sample and at the same time agitate the sieve up and down. Any remaining lumps of soil particles that have not disintegrated shall be broken down by hand. After all lumps have been broken down, the sieve and remaining contents shall be held above the water level and washed with a small amount of clean water .

c.) The washed material retained on the 0.425 mm (# 40) sieve in Section A. V. 5.b. shall be transferred to a clean pan and dried at 60ºC (140ºF). After drying, re-sieve the material over a 0.425 mm (#40) sieve. Discard the material retained on the sieve. The material passing the sieve shall be added to material processed in Section A. V.4.

d.) The water and soil mixture from Section A. V. 5.b. shall be set aside, covered tightly and not disturbed until all of the soil particles have settled to the bottom of the pan . Settling usually takes several hours. A normal procedure is to allow the water/soil mixture to set undisturbed over night. As much of the water as possible shall then be decanted or siphoned without removing any of the settled soil particles. The soil remaining in the container shall be dried at a temperature not exceeding 60°C (140°F). The dried soil shall be ground with a mortar and a rubber covered pestle until it will once again pass the 0.425 (# 40) sieve. The material shall be added to the material processed in Section A. V.4.

6. The total material processed from Section A. V. Items 4., 5c. and 5d. shall be thoroughly mixed and tightly covered until further testing is initiated.

The objective is to obtain an air tight seal. One appropriate method is to completely cover the container holding the material with a single sheet of polyethylene plastic wrap. The plastic shall be wrapped tightly around the container edge to insure a continuos tight seal. A container with a lid that will maintain the appropriate seal is also acceptable.

A pan with an area of approximately 500 cm^2 (80 in^2) and a depth sufficient to accommodate the required volume of water.

A suitable container is any container that is able to accommodate the sieve, the sample of soil and the water, which was generated from the washing operation.

A maximum of 5000 mL of clean water shall be used to wash the material.

A slight discoloration of the water may occur when an excess amount of lime is present in the test sample. Decanting or siphoning may be initiated if the water is translucent. An opaque condition is not acceptable.

SECTION B

DETERMINING THE LIQUID LIMIT

I. REFERENCE:

M.A.G. 702.2.3 Plasticity Index.
AASHTO T 89-96 Liquid Limit of Soils
ASTM D 4318-96 Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4643-93 Determination of Water (Moisture) Content of Soil by the Micro Wave Oven Method

II. APPLICATION:

Applies to all contract and permit work.

III. BACKGROUND:

M.A.G. 702.2.3 specifically requires the Plasticity Index be tested in accordance with AASHTO T 146, Method A (Wet Preparation). Because of the increased presence of plastic fines in the aggregate pits, many suppliers are using lime to modify the aggregate in order to meet this criteria. Through laboratory testing, it has been determined that the lime modified aggregates may cause erroneous test results when exposed to air and/or large volumes of water for extended periods of time. Therefore, the AASHTO T 146, Method A procedure will be modified as described herein to reduce the error to acceptable limits. Also, in AASHTO T 89-96, there is a discrepancy in the amount of material to be placed in the cup of the Liquid Limit device. The written description does not conform to the drawing in Figure 3 of the procedure. To clarify the discrepancy, the City of Mesa, through this policy, has adopted the written description to be the correct procedure. The written description in AASHTO T 89-96, Section 6-2 states in part "a sufficient quantity of this mixture shall be placed in the cup above the spot where the cup rests on the base and shall be squeezed and spread with the spatula to level and at the same time trimmed to a depth of 10 mm at the point of maximum thickness."

IV. APPARATUS:

1. Dish - A porcelain dish, preferably unglazed, or similar mixing dish, about 115 mm in diameter.

2. Spatula - A spatula or pill knife having a blade about 75 mm to 100 mm in length and about 20 mm in width.

3. Liquid Limit Device - A manually or mechanically operated device meeting the specifications of AASHTO T 89-96, Sections 3.3.1 or 3.3.2.

4. Grooving Tool - A grooving tool conforming to the critical dimensions shown in AASHTO T 89-96, Figure 1.

5. Gage - A gage, whether attached to the grooving tool or separate, conforming to the critical dimension "d" shown in Figure 1 of AASHTO T 89-96, and may be, if separate, a metal bar 10.0 ±0.2 mm thick and approximately 50 mm long.

6. Containers - a) Containers for drying samples in a conventional oven shall conform to AASHTO T 89-96, Section 3.6.
   b) Containers for drying samples in a micro wave oven shall conform to ASTM D 4643-93.

7. Weighing Apparatus - A balance that has sufficient capacity and conforms to AASHTO M 231, Class G1.

8. Ovens - a) A conventional oven that conforms to AASHTO T 89-96, Section 3.8.
   b) A microwave oven that conforms to ASTM D 4643-93.

NOTE: A micro wave oven may be used in lieu of a conventional oven provided that test results obtained by the micro wave oven have been proven to be comparable to the conventional oven.

V. ADJUSTMENT OF LIQUID LIMIT DEVICE:

1. The Liquid Limit Device shall be inspected to determine that the device is in good working order. The grooving tool shall be inspected to determine that the critical dimensions are as shown in Figure 1 of AASHTO T 89-96.

2. Adjust the height of drop of the cup so that the point on the cup that comes in contact with the

base rises to a height of 10.0 ±0.2 mm. See AASHTO T 89-96, Figure 2 for the proper location of the gage relative to the cup during adjustment.

VI. PROCEDURE:

1. From the sample prepared in Section A, SAMPLE PREPARATION, obtain a sample with a mass of 50± g.

2. The sample shall be placed in the mixing dish and thoroughly mixed with 10 to 12 mL of distilled or demineralized water by alternately and repeatedly stirring, kneading and chopping with a spatula. Additional increments of water (1 to 3 mL) shall be added until the soil/water mixture reaches a stiff but malleable consistency. Each increment of water shall be mixed with the soil as previously described before another increment is added. Once the consistency is reached, the test may begin. At this point, no additional dry soil should be added to the moistened soil. The cup of the Liquid Limit device shall not be used for mixing soil and water. If too much moisture has been added to the sample, the sample shall either be discarded or mixed and kneaded until natural evaporation lowers the closure point on the Liquid Limit device to the acceptable range (see Section B. VI. 4.). Should the remainder of the test procedure be delayed for more than a few minutes, tightly cover the sample until the test is resumed.

3. A sufficient quantity of the soil/water mixture shall be placed in the cup above the spot where the cup rests on the base and shall be squeezed and spread with the spatula to a depth of 10.0 mm at the point of maximum thickness, tapering to form an approximate level surface. As few strokes of the spatula as possible shall be used. Care shall be taken to prevent the entrapment of air bubbles within the mass. The excess soil shall be returned to the mixing dish. The soil in the cup of the device shall be divided by a firm stroke of the grooving tool along the diameter through the centerline of the cam follower so that a clean sharp groove of the proper dimensions will be formed. To avoid tearing of the sides of the grove or slipping of the soil cake in the cup, up to six strokes from front to back or back to front counting as one stroke, shall be permitted. The depth of the groove should be increased with each stroke and only the last stroke should scrape the bottom of the cup.

4. The cup containing the sample prepared in Section B. VI. 3. shall be lifted and dropped between 22 and 28 blows by turning the crank at the rate of approximately two revolutions per second until the two sides of the of the sample come in contact with each other for a distance of 13± mm at the bottom of the groove. The base of the machine shall not be held with the free hand while the crank is turned.

   NOTE: Some soils tend to slide on the surface of the cup instead of flowing. If this occurs, more water should be added to the sample, the sample re-mixed and retested per Section B. VI. Items 3 & 4. If the soil continues to slide on the cup at a lesser number of blows that 25, the test is not applicable and a note should be made that the liquid limit could not be determined.

5. After obtaining a closure of 13± mm in the acceptable range of blows (25 ±3), immediately return the soil in the cup to the mixing dish and, without adding more water, repeat the procedures as directed in Section B. VI. Items 3 & 4. If the second closure is within the acceptable range and within two (2) blows of the first closure, secure a moisture content as directed in Section B. VI. 6.

6. A slice of soil approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, shall be removed and placed in a suitable container. If a conventional drying oven is used to determine the moisture content, the sample shall be dried in accordance with AASHTO T 265. If a micro-wave oven is to be used, the moisture content the sample shall be dried per ASTM D 4643-93.

VIII. CALCULATIONS:

1. The percent moisture of the soil shall be expressed as the moisture content of the mass of the oven-dried soil and shall be calculated as follows:

   Mass of water = mass of soil and water mixture – mass of oven dry soil

   $$\text{Percent Moisture} = \frac{\text{Mass of water}}{\text{Mass of oven dried soil}} \times 100$$

   Calculate the percent moisture to the nearest whole percent.

2. Calculate the Liquid Limit by multiplying the percent of moisture by the factor from Table 1 corresponding to the number of blows required for the second closure.

   Liquid Limit = Percent of Moisture x Factor @ Number of Blows

TABLE 1

Number of Blows	Factor
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.022

The objective is to obtain an air tight seal. One appropriate method is to completely cover the container holding the

material with a single sheet of polyethylene plastic wrap. The plastic shall be wrapped tightly around the container edge to insure a continuos tight seal. A container with a lid that will maintain the appropriate seal is also acceptable.

SECTION C

DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX

I. REFERENCE:

M.A.G. 702.2.3 Plasticity Index (P.I.).
AASHTO T 90-96 Plastic Limit and Plasticity Index of Soils
ASTM D 4318-96 Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4643-93 Determination of Water (Moisture) Content of Soil by the Micro Wave Oven Method

II. APPLICATION:

Applies to all contract and permit work.

III. BACKGROUND:

M.A.G. 702.2.3 specifically requires the Plasticity Index be tested in accordance with AASHTO T 146 Method A (Wet Preparation). Because of the increased presence of plastic fines in the aggregate pits, many suppliers are using lime to modify the aggregate in order to meet this criteria. Through laboratory testing, it has been determined that the lime modified aggregates may cause erroneous test results when exposed to air and/or large volumes of water for extended periods of time. Therefore, the AASHTO T146, Method A procedure will be modified as described herein to reduce the error to acceptable limits.

IV. APPARATUS:

1. Dish - A porcelain evaporating dish, or similar mixing dish about 115 mm in diameter.

2. Spatula - A spatula or pill knife having a blade about 75 mm in length and about 20 mm in width .

3. Surface for Rolling - A ground glass plate or piece of smooth unglazed paper.

4. Containers - a) Containers for drying samples in a conventional oven shall conform to AASHTO T 89-96, Section 3.6.
   b) Containers for drying samples in a microwave oven shall conform to ASTM

D 4643-93.

5. Weighing apparatus - A balance that has sufficient capacity and conforms to AASHTO M 231, Class G1.

6. Ovens - a) A conventional oven that conforms to AASHTO T 89-96, Section 3.8.
b) A microwave oven that conforms to ASTM D 4643-93.

NOTE: A micro wave oven may be used in lieu of a conventional oven provided that test results obtained by the micro wave oven have been proven to be comparable to the conventional oven.

V. SAMPLE:

1. If only the Plastic Limit is required, take a quantity of soil with a mass of 20? g from the sample prepared in accordance with Section A, SAMPLE PREPARATION. Place the sample in a mixing dish and thoroughly mix with distilled or demineralized water by alternately stirring, kneeling and chopping with a spatula until the mass becomes plastic enough to be easily shaped into a ball. Take a test sample with mass of 8? g from the ball.

2. If both the liquid and plastic limits are required, take a test sample with a mass of 8? g from the sample prepared in accordance with Section B, DETERMING THE LIQUID LIMIT . Take the sample at any stage of the mixing process (Section B.VI.2.) at which the mass becomes plastic enough to be easily shaped into a ball without excessively sticking to the fingers when squeezed. If the sample taken during the liquid limit test is too dry to permit rolling to a 3.2 mm (1/8") thread, add more water and remix.

VI. PROCEDURE:

1. Squeeze and form the 8? g test sample taken in accordance with Section C. V. into an ellipsoidal-shape mass. Roll the mass between the fingers or palm and the ground-glass plate or a piece of paper laying on a smooth horizontal surface. Exert just enough or sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling shall be between 80 and 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position again.

2. When the diameter of the thread becomes 3.2 mm (1/8"), break the thread into six or eight pieces. Between the thumbs and fingers of both hands, squeeze the pieces together into a uniform mass roughly ellipsoidal in shape and re-roll. Continue this alternate rolling, gathering, kneading and re-rolling, until the thread crumbles under the pressure required for rolling. The crumbling may occur when the thread has a diameter greater than 3.2 mm (1/8"). This shall be considered a satisfactory end point, provided the soil has been rolled successfully into a thread of 3.2 mm (1/8") in diameter in the previous rolling.

NOTES:

1.) As the cylindrical length increases during rolling, slight pressure differences may cause small pieces of the material to break away. This shall not be considered a satisfactory end point, or as the basis for a non-plastic determination, provided that the mass of the pieces(s) does not exceed 5% of the original sample mass and that the remainder can be rolled to a uniform 3.2 mm (1/8") thread.

2.) The crumbling will manifest itself differently with the various types of soil. Some soils fall apart in numerous small aggregations of particles; others may form an outside tubular layer that starts splitting at both ends. The splitting progresses toward the middle and finally, the thread falls apart in many platy particles. Heavy clay soil requires greater pressure to deform the thread, particularly as they approach the plastic limit, and finally, the thread breaks into a series of barred-shaped segments each about 6.4 (1/4") to 9.5 mm (3/8") in length. At no time shall the operator attempt to produce failure at exactly 3.2 mm (1/8") diameter by allowing the thread to reach 3.2 mm (1/8"), then reducing the rate of rolling or the hand pressure or both, and continuing the rolling without further deforming until the thread fall apart. However, it is permissible to reduce the total amount of deformation for feebly plastic soils by making the initial diameter of the ellipsoidal-shaped mass nearer to the required 3.2 mm (1/8") final diameter.

3.) Once the test has reached it's satisfactory end point, gather the portions of the crumbled soil together and place in a container. If the sample is to be dried in a standard oven, proceed in accordance with AASHTO T 265. If a microwave oven is to be used, dry the sample in accordance with ASTM D 4643-93.

IV. CALCULATIONS:

1. Calculate the Plastic Limit expressed as the moisture in percent of the mass of the oven-dry soil, as follows :

   Mass of Water = mass of soil and water mixture - mass of oven dry soil

   $$\text{Plastic Limit} = \frac{\text{Mass of water}}{\text{Mass of oven dried soil}} \times 100$$

   Report the Plastic Limit to the nearest whole number.

2. Calculate the Plasticity Index as the difference between the Liquid Limit and the Plastic Limit as follows:

   Plasticity Index = Liquid Limit - Plastic Limit

3. Report the Plastic Index as a whole number except as follows:
   a) When the Liquid Limit or Plastic Limit cannot be determined, report the Plasticity Index as N. P. (non-plastic).
   b) When the Plastic Limit is equal to or greater than the Liquid Limit, report the Plastic Index as N. P.

The objective is to obtain an air tight seal. One appropriate method is to completely cover the container holding the material with a single sheet of polyethylene plastic wrap. The plastic shall be wrapped tightly around the container edge to insure a continuos tight seal. A container with a lid that will maintain the appropriate seal is also acceptable.

This POLICY shall become effective this 24 day of March, 1999.

s/ Jack Friedline
Jack FRIEDLINE
Public Works Manager

s/ Keith Nath
Keith NATH
City Engineer